An Ensemble approach-based prediction model for Atrial Fibrillation

Short Synopsis

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by

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Certificate

I hereby declare that the short synopsis "An Ensemble approach-based prediction model for Atrial Fibrillation" being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Data Mining under faculty of Computer Science and Engineering of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2022-23.

It is a bonafide record of original work carried out under the supervision of Dr. Rosy Madaan, Associate Professor, CSE, SET, MRIIRS and has not been submitted in full or part to any other University or institute for degree or diploma.

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ABSTRACT

In this era of electronic health, healthcare data has gained significant popularity due to its high influence on human survival information. As a pictorial representation of healthcare data, an ElectroCardioGram (ECG) can be used to identify many cardiac diseases. One such cardiac disease indicated by ECG is Atrial Fibrillation (AF). AF is a condition in which the heart rhythm is disrupted, and is often accompanied by other health complications, such as strokes and heart failure. Predictions of AF possess some of its own challenges. This is because of its asymptomatic and episodic nature, which may result in reducing mortality levels as well as reducing the economic stress associated with the disease.

Manually analysing the ECG is part of clinical practice to predict AF, which can take a lot of time and effort. Also, the manual study of ECG requires high expertise and is subject to observer variability. To treat AF effectively, there is a necessity for developing an automated system that can be used to predict AF.

Based on this concept, this study intends to present a computerized approach that can be applied to the prediction of AF through ECG using data mining and machine learning. As predicting AF from ECG is challenging, only a few strategies have been examined at present in the state of the art. Further this research will be focussed on to investigating new feature extraction algorithms and different combinations of data mining techniques to increase accuracy using ensemble learning. The objective of this work is to provide an outline of the upcoming research objectives. It also outlines the methodology to be used and the anticipated results. This work aims to contribute to the development of a prediction model that can assist in predicting AF events efficiently and accurately.

Keywords: Atrial fibrillation, Classification, Data Mining, Electrocardiogram, Machine Learning, Prediction.

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1. INTRODUCTION

Modern and rapidly changing lifestyles of individuals have resulted in an inevitable rise in heart-related problems, including chest pain, difficulty breathing, irregular blood pressure, and an irregular heartbeat. In the world of heart disease, there are several types of arrhythmias known for their fast and irregular heartbeats. Atrial fibrillation is one of those types, and it is defined by its rapid and uneven heartbeat. At first, it was a paroxysmal condition. Within a few days, it progresses to persistent AF, and within one year, it develops into permanent AF, which directly contributes to strokes, heart failure, and other complications. Heart disease has been the leading cause of mortality for the last ten years. According to the European Public Health Alliance, most deaths across the globe are caused by circulatory diseases such as heart attacks and strokes. These diseases account for more than 41% of all deaths (Mensah, G. A., Roth, G. A., Ademi, Z., 2020). Reports show that most of the diseases were non-communicable diseases like cancer, chronic respiratory disorders, cardiovascular diseases, and diabetes. In addition to the Economic and Social Commission of Asia, the reports have impacted one-fifth of Asian countries. According to the Australian Bureau of Statistics, around 33.7% of Australians die as a result of heart and circulatory system problems (Vos, T., Lim, S.S., et al., 2020). According to South African data, heart and circulatory system problems are the foremost cause of death in Africa. Every year, the number of people who die from heart disease increases. The average cost of treatment of heart disease is also very high (Forouzanfar, M.H., Afshin, A., et al., 2016). That is one of the reasons why healthcare companies are under increasing pressure to improve the quality of the healthcare system and reduce costs. These considerations led to the need for a prediction model that can predict the disease and its risk.

Heart-related problems can take many different forms in the human body. An example would be arrhythmia or irregular heartbeats. This type of cardiac arrhythmia impacts 46.3 million people globally (Svennberg, E., et al., 2022). Among the various methods of predicting AF, the ECG is one of the most used. The incidence of this type of arrhythmia continues to rise every year around the world. To assist in the early prediction of diseases and their risk as a result of these problems, there is a need for a computerized system that can assist in the early detection of diseases and their risk.

1.1 Introduction to Atrial Fibrillation

Electrical impulses that travel around and through the heart establish the rhythm of the heart. These impulses are initially generated by the sinoatrial node of the heart. Following this, they move through a network of fibers to reach each chamber of the heart. This electrical pattern allows the heart's chambers to pump out blood and then relax and fill with blood in a controlled sequence (Chao, T.F., Joung, B., *et al.* 2022). It keeps blood flowing steadily throughout the body. Arrhythmias are changes in the electrical activity of the heart, which result in unusual or unpredictable patterns of heartbeats. AF is one of the arrhythmias that poses a challenge for healthcare systems around the world (Zhou, Y., Suo, W., Zhang, X., Lv, J., *et al.*, 2022). AF occurs when the beats of the atrium of the heart are rapid and irregular (Romiti, G.F., Pastori, D., *et al.* 2022). It usually begins as short periods of abnormal beating, which becomes more frequent and continuous with time.

AF being a life-threatening disease has attracted the attention of researchers. The same has been demonstrated in several clinical studies (Rizwan A., Zoha A., Mabrouk I.B., Sabbour H.M., et al., 2020). An AF can result in blood clots in the heart which in can further led other health problems.

1.2 Role of ECG signals in prediction of AF

The ECG signal is the most used tool for predicting AF. It is defined by its P-waves, QRS complexes, and T-waves, which show depolarization of the atrium, depolarization of the ventricular chambers, and repolarization respectively. The peak point of an ECG is the R-peak, and the RR interval is the duration between two succeeding R-peaks. Analysing the amplitude, shape, and duration of these waves, the operational well-being state of the heart can be predicted. Various ECG points are shown in Figure 1 below.

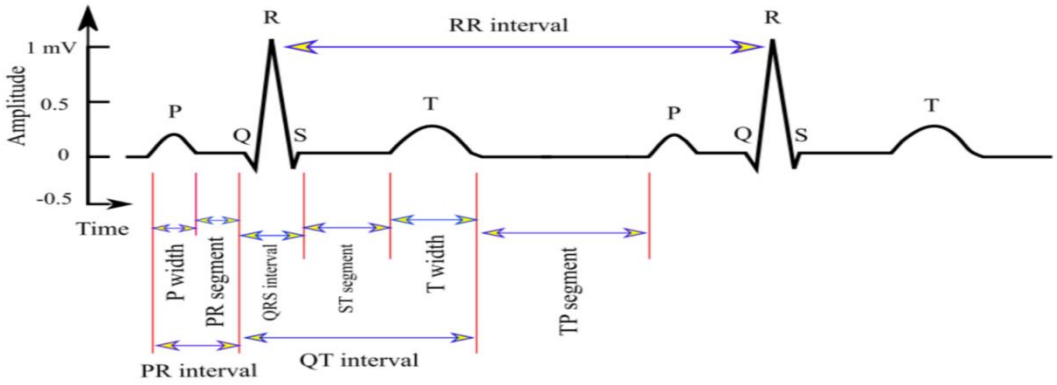

Figure 1: Overview of ECG points (Source: Hamil, H., Zidelmal, Z., et al., 2021)

Now the presence of AF rhythms in a patient is studied through ECG signals. ECG signals are basically the identification of electrical activity of the heart (Vos, T., Lim, S.S., *et al.* 2020). It is a pictorial healthcare data which is used to identify AF (Morillo, C.A., Banerjee, A., *et al.* 2017). This data is read manually by the experts or doctors to predict the presence of AF in a patient identified with cardiac issues. A manual study of ECG to predict AF is laboratory intensive, time-consuming, and requires high levels of expertise (Forouzanfar, M.H., Afshin, A., *et al.* 2016). It is important to predict and classify AF early and automatically in order to be able to treat it effectively. It has been found to be profitable to predict arrhythmias using ECG when it comes to atrial fibrillation in the early stages. Data mining and machine learning methods are some of the presently utilized computerized techniques to identify AF using ECG signals.

2. LITERATURE REVIEW

Research on determining a prediction model of AF through ECG signals involves pre-processing the ECG signals, extracting relevant and prominent features from the ECG signals, and finally building a model to predict the AF.

With 23 ECG signals of about 10 h each, **Jahan, M.S., Mansourvar, M., Puthusserypady, S., Wiil, *et al.*, (2022)** proposed ML-based computerized method for predicting short-term episodes of AF. "SVM, DT, RF, SC, XGBoost, and Adaptive Boosting AdaBoost" are the ML models that were utilized, among which some of them demonstrated high performance and flexibility**.** Three datasets were examined, which includes the "Long-Term AF dataset, the MIT-BIH Arrhythmia dataset, and the MIT-BIH Normal Sinus Rhythm datasets".

By employing CNN, **Mendez, M.M., Hsu, M.C., Yuan, J.T. and Lynn, K.S., (2022)** predicted Paroxysmal AF (PAF) based on input image matrices using three PhysioNet databases. With approximately 5 min long HRV sequence and applying recurrence plot representations to Poincaré images the proposed system achieved an accuracy of 87.2%.

Rahul, J. and Sharma, L.D., (2022), used CNN and Bi-LSTM to identify cardiac arrhythmias automatically. For this study, three PhysioNet databases were consulted: "MIT-BH, CUDB, and VFDB". These data were pre-processed by applying "stationary wavelet transforms, a two-

stage median filter, and Savitzky-Golay". Using the proposed method, cardiac arrhythmia beats can be classified accurately and reliably.

Prediction of AF using the SFMM model congestion with an embedded system was explained by **Huang, W., Zhang, Y. and Wan, S., (2022)**. Author demonstrated the potential of SFMM-based embedded system through experimental results on AF. The SFMM model is evaluated using ML benchmarks with the control and the ADC chip, which has a great level of common-mode rejection ratio (CMRR).

Petmezas, G., Haris, K., Stefanopoulos, L., *et al.*, (2021) balanced training data imbalances with "CNN and LSTM models". They used a conventional cross-validation strategy to validate the model performance. The "MIT-BIH AF Database" was utilized to obtain the imbalance datasets. The model displayed a sensitivity of 97.87% and a specificity of 99.29%.

Castro, H., Garcia-Racines, J.D. and Bernal-Norena, A., (2021) Predicting PAF episodes in ECG signals through ML models. RF, conditional RF, KNN and SVM are the ML models described by the author. Based on ECG signals from PhysioNet's AF prediction database, 106 signals from 53 pairs of ECG recordings were analysed.

Wang, L.H., Yan, Z.H., Yan *et al.*, (2021) predicted onset of AF through "Hybrid Improved Quantum Particle Swarm Optimization (IQPSO) and SVM". The authors used the "MIT-BIH database". The study presents a technique for extracting features from various databases using SVM. To evaluate the effectiveness of the proposed approach, the performance was assessed using three databases: "AFDB, AFPDB, and FZU-FPH". The SVM classifier, trained with 14 features that describe both time and frequency domains, achieved exceptional results in the diagnosis model when tested on the AFDB database. The model exhibited a remarkable sensitivity, specificity, and accuracy of 99.2% each.

"Stockwell transform (ST) in congestion with compact support kernel (ST-CSK)" was explored by **Hamil, H., Zidelmal, Z., et al., (2021)** for AF analysis using ECG signals. SVM was used for AF recognition in this study. The databases came from Physionet. Recorded ECG signals were collected on the MySignals HW development platform. The method achieved 98.46% sensitivity and 97.81% specificity.

In their study, **Kumari, C.U., Murthy, A.S.D., et al. (2021)** introduced a technique that utilizes "SVM models for the classification of different arrhythmias". The ECG signals sourced from

the “MIT-BIH database” were partitioned into training and testing sets, maintaining a ratio of 7:3. Through data preparation procedures, a total of 190 features were extracted. Notably, the SVM-based model achieved an accuracy of 95.92%.

ECG analysis and arrhythmia prediction using Sequential Minimal Optimization (SMO) was done by **Jannah, N., Hadjiloucas, S. and Al-Malki, J., (2021).** In this model, the risks of AF are analyzed using BASIC-AF risk scores, which include biomarkers, ages, ultrasounds, ventricular conduction delays, and clinical history. **Samaras, A., Kartas, A., *et al.* (2021)** proposed a risk-based prediction model for AF. In this model, the risks of AF are analyzed using BASIC-AF risk scores, which include biomarkers, ages, ultrasounds, ventricular conduction delays, and clinical history.

Utilizing “MIT-BIH AF and Physiological Signal Challenge of China 2018” database the prediction of AF using recurrent “NN and LSTM” was done by **Auliya, G. and Effendi, J., (2021)**. Performance of LSTM in terms of sensitivity, accuracy, precision, specificity, as well as F1-score was evaluated and it was found that each of them were more than 94%.

Wu, X., Zheng, Y., Chu, C.H. and He, Z., (2020) defined features to capture variation in short ECG segments. The study was carried out on “MIT-BIH AF dataset, Physionet challenge 2017 and MIT-BIH Normal Sinus Rhythm dataset through LR, KNN, CART, SVM, RF and XGBoost models”. The work resulted in excellent results for classifying AF through RF. Through XGBoost, signals are classified with an F1 score of 0.88.

Detection of AF from short term ECGs through CNN models was done by **Nurmaini, S., Tondas, A.E., Darmawahyuni, A., *et al.* (2020)**. We tested the robustness of the proposed model using four datasets and found that 1D-CNNs performed better than other approaches and were superior to other approaches in terms of performance and generalization. Two classes had 99.98% accuracy, 99.91% sensitivity, 99.91% specificity, 99.99% precision, and 99.95% F1-scores.

Chen, Y.H., Twing, A.H., *et al.*, (2020) predicted the potential AF risk model using CNN. The dataset was collected from the “University of Illinois Hospital and Health Sciences System”. Model was processed on both ECG data and other health data related to AF. This was found that AF prediction is more accurate with ECG signals compared to other related health data.

Bashar, S.K., Han, D., *et al.*, (2020) explored "KNN, SVM, and RF" models to detect AF from premature atrial contractions. An ECG signal-based "density Poincaré plot-based machine learning method" was developed to detect AF from PAC. SVM achieved the best performance with speciality, sensitivity, and accuracy of 95.18%, 98.99%, and 97.45%, respectively.

Subramania, K. and Prakash, N.K., 2020 utilized SVM classification model to identify different disease conditions through ECG signals. At first the ECG signals are filtered to remove power line interface. As a result of segmenting this filtered signal, ECG features are extracted accurately. This methodology produced an accuracy of 91%.

Hulme, O.L., Khurshid, S., *et al.*, (2019) explored the possibility of determining AF through ECG signals. Real time ECG signals were utilized for this study. In this study, a prediction model for 5 years AF risk was derived and validated by split-sample validation. The model performance was evaluated by comparing its result with other classification models.

A fully automatic and fast ECG arrhythmia classifier using Ensemble Echo State Networks was developed by **Alfaras, M., Soriano, M.C. and Ortín, S., (2019)**. In the "MIT-BIH AF dataset", the classification model indicated a sensitivity of 92.7% and accuracy of 93%.

Ayoubkhani, D., Hill, N. R., et al., (2019) used "NN, LASSO, random forests, SVM, and Cox regression classifiers to classify Clinical Practice Research database". In comparison to CHARGE-AF, time-varying NN achieved 75% sensitivity based on an analysis of 2,994,837 individuals.

Cui, X. et al., (2019) predicted AF recurrence before catheter ablation (CA) using an "adaptive nonlinear and non-stationary surface ECG analysis". The study indicated that the patients that maintained sinus rhythm of 152.2 ms or more have no sign of recurrence of AF.

Budzianowski, J. et al. (2019) conducted a study to evaluate the predictive significance of laboratory and clinical parameters associated with early recurrence of AF following cry balloon ablation (CBA). The research employed statistical analysis and ML algorithms for this assessment. The study revealed that troponin-T and creatine kinase-MB, which are biomarkers indicating myocardial injury, play a role in the early recurrence of AF after CBA. These findings were further corroborated by the ML algorithms employed in the study.

"Naive Bayes, RF, k-NN, SVM Linear Classification algorithms" are used by **Gomes, C., Cardoso, A., Silveira, T., *et al.*, (2018)** for detection of Cardiac Arrhythmia. The study was done on the dataset provided by UCI. Among all the classification models developed RF resulted in 88% of accuracy, 89.8% of sensitivity and 88.76% of specificity.

The performance of the SVM model trained with 13 features outperformed the one trained with 72 features according to **Trardi, Y., Ananou, B., Haddi, Z. and Ouladsine, M. (2018).**

Szilagyi, J., Walters, T. E. et al., (2018) aimed to identify electrocardiographic and intracardiac measures that could serve as predictors of AF recurrence following the procedure. The results concluded that surface ECG and intracardiac spectral measures can provide valuable predictive information regarding the likelihood of AF recurrence after CA.

Simantirakis, E. N. et al., (2018) findings demonstrated that the overall recurrence rate of AF after the first clinical episode was 61.9%. The median time to recurrence was 7.5 months. The researchers observed that patients with a longer duration of the first AF episode had a higher risk of recurrence. Additionally, patients who had other cardiovascular comorbidities, such as hypertension or heart failure, were also more likely to experience AF recurrence.

In Table 1, various studies on predictors of AF from the existing studies are reviewed and presented.

Table 1: Review of existing studies (Source: self)

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
Jahan, M.S., Mansourvar, M., Puthusserypady, S., Wiil, *et al.*, 2022.	"Short-term atrial fibrillation detection using electrocardiograms: A comparison of machine learning approaches"	SVM, DT, RF, SC, XGBoost and AdaBoost	Using 23 ECG records of approximately 10 hours length, the results were 85.67% sensitivity, 81.25% specificity, 90.85% positive predictive value, 18.75% false positive rate, and 88.18% F1-score.	Model developed cannot be used to predict AF in all cases.
Mendez, M.M., Hsu, M.C., Yuan, J.T., Lynn, K.S., 2022	"A Heart Rate Variability-Based Paroxysmal Atrial Fibrillation Prediction System"	CNN and Recurrence plot representation used to Poincaré images	With approximately 5 min long HRV sequence and applying recurrence plot representations to Poincaré images the proposed system achieved an accuracy of 87.2%.	High Computational Time.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
Rahul, J. and Sharma, L.D., 2022	"Automatic cardiac arrhythmia classification based on hybrid 1-D CNN and Bi-LSTM model"	Pre-processing: Stationary wavelet transforms, two-stage median filter, S–Golay Model: CNN, Bi-LSTM	This paper used 1-D CNN for feature extraction and Bi-LSTM for classification to achieve an accuracy of 99.41%.	Limited ECGs were used due to which a features were not properly covered.
Huang, W., Zhang, Y. and Wan, S., 2022	"A Sorting Fuzzy Min-Max Model in an Embedded System for Atrial Fibrillation Detection"	Sorting fuzzy min-max (SFMM) model	For the control chip and ADC chip of the embedded system based on SFMM, ML will be used to analyze performance.	Dataset having limited ECG signals were used.
Petmezas, G., Haris, K., Stefanopoulos, L., *et al.*, 2021	"Automated atrial fibrillation detection using a hybrid CNN-LSTM network on imbalanced ECG datasets"	CNN and LSTM model and used conventional cross validation strategy to evaluate model performance	MIT-BIH AF Database was used to obtain imbalance datasets, and the model's sensitivity and specificity were 97.87% and 99.29%, respectively.	Conventional cross validation used which takes more time and cost.
Castro, H., Garcia-Racines, J.D. and Bernal-Norena, A., 2021	"Methodology for the prediction of paroxysmal atrial fibrillation based on heart rate variability feature analysis"	Preprocessing: Windowing, HRV signal, Resample, detrending Models: RF, conditional RF, KNN, SVM	106 signals from 53 pairs of ECG recordings were analysed on the proposed method and it resulted in a precision of 93.24%.	Model developed cannot be used to predict AF in all cases.
Wang, L.H., Yan, Z.H., Yan *et al.*, 2021	"A classification and prediction hybrid model construction with the IQPSO-SVM algorithm for AF arrhythmia"	IQPSO and SVM.	In order to evaluate the performance of the proposed method for extracting features from different databases, the AFDB, AFPDB, and FZU-FPH databases were used. For the diagnosis model, the SVM classifier demonstrated	Outcomes not compared with previous model.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
			sensitivity, specificity, and accuracy of 99.2% .	
Hamil, H., Zidelmal, Z., *et al.*, 2021	"AF episodes recognition using optimized time-frequency features and cost-sensitive SVM"	ST with compact support kernel was for analysis. After that, SVM was used for AF recognition.	This work utilized SVM was for AF recognition. Recorded ECG signals were collected with the MySignals HW development platform. Its sensitivity and specificity were 98.46% and 97.81%, respectively.	High speed real-time detection and classification.
Kumari, C.U., Murthy, A.S.D., *et al.*., 2021	"An automated detection of heart arrhythmias using machine learning technique: SVM"	Preprocessing and Feature Extraction: DWT Classification Model: SVM	MIT-BIH ECG signals were divided into 7:3 training and testing sets. 190 features were extracted. It was determined that the SVM-based model had 95.92% accuracy.	Dataset having limited ECG signals were used.
Jannah, N., Hadjiloucas, S. and Al-Malki, J., 2021	"Arrhythmia detection using multi-lead ECG spectra and Complex Support Vector Machine Classifiers"	Pre-processing: QRS detection, RR interval analysis. Feature Extraction: DFT Classification Model: SMO	In this model, the risks of AF are analyzed using BASIC-AF risk scores, which include biomarkers, ages, ultrasounds, ventricular conduction delays, and clinical history.	Not all types of ECG beats are recognized from this study.
Samaras, A., Kartas, A., *et al.* 2021	"A novel prognostic tool to predict mortality in patients with atrial fibrillation: the BASIC-AF risk score"	Model was based on BASIC-AF risk score analysis which includes Biomarkers, Ages, ultrasounds, and Clinical history.	The author proposed a risk-based prediction model for AF. In this model, the risks of AF are analysed using BASIC-AF risk scores, which include biomarkers, ages, ultrasounds, ventricular conduction delays, and clinical history.	Medium-sized patient sample and single-center nature.
Auliya, G. and Effendi, J., 2021	"Detection of Atrial Fibrillation Based on Long Short-Term Memory"	Discrete Wavelet transform, recurrent NN	Utilizing MIT-BIH AF and China Physiological Signal Challenge 2018 database the prediction of AF using recurrent NN and LSTM was done by the author. A LSTM was evaluated	Feature extraction is not done.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
			in terms of accuracy, sensitivity, specificity, precision, and F1-score, and was found to have above 94% accuracy, specificity, and precision.	
Wu, X., Zheng, Y., Chu, C.H. and He, Z., 2020	"Extracting deep features from short ECG signals for early atrial fibrillation detection"	LR, KNN, CART, SVM, RF and XGBoost were used to evaluate the performance for detecting early AF.	The work defined features to capture variation in short ECG segments. The study was carried out through LR, KNN, CART, SVM, RF and XGBoost models. The work resulted in excellent results for classifying AF through RF, with 0.96 F1 score.	Datasets clearly label other disease information.
Nurmaini, S., Tondas, A.E., Darmawahyuni, A., *et al.* 2020	"Robust detection of atrial fibrillation from short-term electrocardiogram using convolutional neural networks"	Pre-processing: normalization, noise removal, and segmentation using discrete wavelet transform Classification Model: CNN	Detection of AF from short term ECGs through CNN models was done in this work. 04 datasets were utilized to evaluate the model. The results obtained from the proposed approach outclassed other methods in terms of performance and generalization ability. Two classes had 99.98% accuracy, 99.91% sensitivity, 99.91% specificity, 99.99% precision, and 99.95% F1-scores.	Undetectable starting point of AF Larger and more varied data required to reach accuracy.
Chen, Y.H., Twing, A.H., *et al.*, 2020	"Atrial Fibrillation Risk Prediction from Electrocardiogram and Related Health Data with Deep Neural Network"	Preprocessing: Sampling Feature Extraction: V5 Channel extraction, Augmenting, flip and rotation. Classification Model: CNN	The dataset was collected from the University of Illinois Hospital and Health Sciences System. Model was processed on both ECG data and other health data related to AF. This was found that AF prediction is more accurate with ECG signals compared to other related health data.	Dataset having limited ECG signals were used.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
Bashar, S.K., Han, D., *et al.* 2020	"Novel density Poincaré plot based machine learning method to detect atrial fibrillation from premature atrial/ventricular contractions"	Non overlapping segmentation, Density Poincare Plot Generation, Moment Based Features, Zernike Moments, KNN, SVM, RF	KNN, SVM, and RF models were used to detect AF from premature atrial contractions using an ECG signal-based density Poincaré plot-based machine learning method. SVM performed the best, achieving 98% sensitivity, 95% specificity, and 97% accuracy.	Without QRS detection overall efficiency of the model reduces.
Subramania, K. and Prakash, N.K., 2020	"Machine Learning based Cardiac Arrhythmia detection from ECG signal"	Preprocessing: Noise removal, QRS detection Classification Model: SVM	The work utilized SVM classifier to identify different disease conditions through ECG signals. In order to extract features from ECG signals accurately, the filtered signal is segmented into smaller pieces, so the power line interface can be removed. This methodology resulted in a 91% accuracy rate.	Dataset having limited ECG signals were used.
Hulme, O.L., Khurshid, S., *et al.* 2019	"Development and validation of a prediction model for atrial fibrillation using electronic health records"	Sampling, denoising, baseline removal, segmentation and normalization.	Real time ECG signals were utilized for this study. In this study, a prediction model for 5 years AF risk was derived and validated by split-sample validation. The model performance was evaluated by comparing its result with other classification models.	Data collected from limited area which reduces its generalization.
Alfaras, M., Soriano, M.C. and Ortín, S., 2019	"A fast machine learning model for ECG-based heartbeat classification and arrhythmia detection"	Echo State networks ML approach is used in MIT-BH and AHA dataset.	For ventricular ectopic beats detected with lead II, there is a sensitivity of 92.7% and PPV of 86.1%, and with lead V1', the sensitivity is 95.7% and PPV is 75.1%.	High false alarm rate.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
Hill, N. R., Ayoubkhani, D., et al., 2019	"Predicting atrial fibrillation in primary care using machine learning	NN, LASSO, random forests, SVM and Cox regression.	In comparison with the best existing model CHARGE-AF, 2,994,837 individual observations showed that the time-varying NN achieved 75% sensitivity.	Poor generalization.
Cui, X. et al., 2019	"Prediction of atrial fibrillation recurrence before catheter ablation using an adaptive nonlinear and non-stationary surface ECG analysis"	Nonlinear and non-stationary signal analysis technique	To study Atrial fibrillation cycle length nonlinear and non-stationary signal analysis technique was explored. Results found that to be adaptive, non-invasive and accurate.	Study was limited to the sample size of 28 patients only.
Budzianowski, J. et al., 2019	"Predictors of atrial fibrillation early recurrence following cryoballoon ablation of pulmonary veins using statistical assessment and machine learning algorithms"	Synthetic minority over-sampling technique was used to provide a balanced training data set.	Statistical assessment and ML algorithms were used to assess the predictive value of laboratory and clinical parameters associated with early AF recurrence after CBA. ML confirmed that troponin-T and creatine kinase-MB are biomarkers of myocardial injury associated with early AF recurrence.	Small Sample size.
Gomes, C., Cardoso, A., Silveira, T., et al., 2018	Combining data mining techniques to enhance cardiac arrhythmia detection"	Naive Bayes, Random Forest, k-NN, SVM Linear Classification algorithms.	The study was performed to detect Cardiac Arrhythmia. The study was done on the dataset provided by UCI. Among all the classification models developed RF resulted in 88% of accuracy.	Poor factor analysis.
Trardi, Y., Ananou, B., Haddi, Z. and Ouladsine, M., 2018	"A Novel Method to Identify Relevant Features for Automatic Detection of Atrial Fibrillation"	Preprocessing: QRS estimation, time segmentation, RR-dynamics. Feature Extraction:	"The obtained results showed that the SVC model trained by 13 features outperformed the one trained by 72 features. This approach has reached 99.77% of success rate in the discrimination	Dataset having limited ECG signals were used.

Author Name, Year	Title	Methodology Used	Outcomes	Gaps
		Multiple Kernel Learning (MKL) Classification Model: SVM	between Normal Sinus Rhythm and AF."	
Szilagyi, J., Walters, T. E. et al., 2018	"Surface ECG and intracardiac spectral measures predict atrial fibrillation recurrence after catheter ablation"	Clinical study included 104 patients who underwent CA for AF and were monitored for 18 months.	The authors conclude that surface ECG and intracardiac spectral measures can provide valuable predictive information regarding the likelihood of AF recurrence after CA.	Results were not validated.
Simantirakis, E. N. et al., 2018	"Recurrence rate of atrial fibrillation after the first clinical episode: A prospective evaluation using continuous cardiac rhythm monitoring"	The study included 105 patients, and their median follow-up period was approximately 16 months.	The author concluded that a significant number of patients suffer no recurrence of their first symptomatic episode or have a low recurrence rate following their first symptomatic episode.	Small Sample size.

The above literature review indicated the ECG signal as the most prominent datasets that can be utilized in defining a classification model for prediction of AF.

3. RESEARCH GAPS

Based on the literature review done so far, the following research gaps have been identified in the state of art:

1. During the prediction of the course of atrial fibrillation, the stages and severity of atrial fibrillation is ignored.
2. Studies by Hill, et al., 2019, Cui, et al., 2019, Trardi, et al. 2018, Simantirakis, et al., 2018, Nurmaini, et al. 2020 have primarily focused on post-onset AF prediction, with limited evidence regarding the feasibility of predicting AF before its onset.

3. AF prediction models lack standardized validation and benchmarking protocols, which are essential for comparing and evaluating them.
4. Multi-scale data such as atrial enlargement, ventricular hypertrophy and organ-level dynamics leading to AF initiation, maintenance, and termination are very rarely considered (Budzianowski, J. et al., 2019; Cui, et al., 2019).

4. DESCRIPTION OF BROAD AREA

4.1 Data Mining

Extraction of a known pattern from a dataset is known as data mining (Sumiran, K., 2018). It includes cleaning of data for noise removal, combining data from varied sources, selection of features, transforming each data into a consistent form and then applying algorithms to obtain a hidden pattern from them (Olson, D.L. and Lauhoff, G., 2019).

Through the use of algorithms and statistical models, machine learning involves adapting a computerized system to find patterns in data. By using sample data, known as training data, machine learning algorithms can make predictions without being specially programmed (Bi, Q., Goodman, K.E., Kaminsky, J. and Lessler, J., 2019). Several applications use machine learning algorithms, including medicine, agriculture, filtering, speech recognition, and computer vision. Conventional algorithms cannot be developed for these applications.

In terms of similarities, both data mining and machine learning have a lot in common, making them a good match for each other. However, while machine learning relies on predicting using known properties learned from training data, data mining seeks to discover properties in data.

4.2 Data Mining and Machine Learning in Healthcare

At present, the field of medicine is far from treating patients with various diseases. Among these, the most dangerous is AF. Incorrect medical decisions result in the death of a patient that no one can afford. In order to make the right decision, a cost-effective computerized treatment and support system can be developed. The health sector is often described as "information rich". This information can be efficiently analyzed to determine a pattern that can be used to

estimate any disease accurately. Once these patterns are studied, they can be adapted into a computerized system through algorithms and statistical models.

It is impossible to obtain useful results without the use of quality data. There are many technical and organizational challenges involved in bringing all real-world data into one centralized repository, since to extract relevant data, different data mining tools and algorithms should be used. As a result, overall performance will be adversely affected if the algorithms are not up to scratch.

5. PROBLEM STATEMENT

The identification of patients suffering from atrial fibrillation requires intensive care in order to prevent AF to the greatest extent. Also, regular monitoring of AF symptoms is must for early prevention and treatment. For this a comprehensive ensemble model needs to be developed.

6. RESEARCH OBJECTIVES

The research objectives framed based on the profound study of past literature are summarized as follows:

1. To review the existing literature on the Atrial Fibrillation, its stages and severity along with possible underlying causes for Atrial fibrillation, both cardiac and non- cardiac.
2. To obtain and pre-process the dataset relevant for the prediction of Atrial Fibrillation.
3. To design a model for the prediction of Atrial Fibrillation using machine learning techniques.
4. To analyse the effectiveness of the proposed approach using various validation strategies.

7. RESEARCH METHODOLOGY

During this study, ECG signals will be used to predict AF. ECG recordings are often corrupted by the body interface, muscle noise, and electrical noise from equipment. Thus, it is necessary to de-noise and filter the signals to get the most accurate possible results. When noise has been removed from the signal, it will be normalized and segmented to produce a uniform pattern. Segmentation is used to locate segments and intervals in the signal so that similar patterns can be identified further. Following the segmentation of the signal, the features will be extracted

from the signal. These features will be used to develop a classification model for predicting AF. Finally, the classification model will be tested on unseen data to evaluate its accuracy and performance.

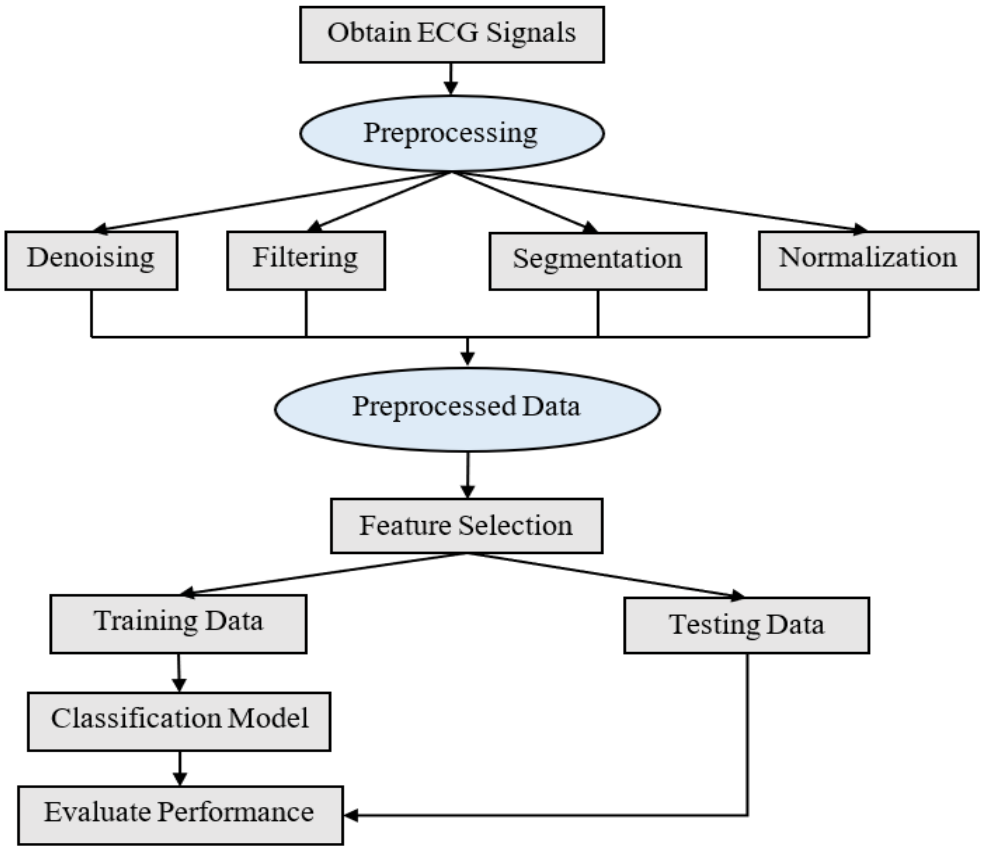

Figure 2: Proposed Methodology (Source: self)

To predict AF, the following methodology will be adopted as shown in Figure 2

1. Review the signs and symptoms of AF.
2. Reviewing and analysing the factors responsible for the occurrence of AF.
3. Collecting ECG signal data from both patients with and without symptoms of AF.
4. Pre-processing the ECG signal.
5. Extracting relevant features from the ECG signals for estimation of the onset of atrial fibrillation.
6. Designing an effective classification model for estimation of the onset of atrial fibrillation.
7. Evaluate the performance of the proposed model.

8. EXPECTED OUTCOME OF RESEARCH

With this research an early prediction model for atrial fibrillation is designed, using data mining and machine learning techniques. In this study, our goal is to reduce or eliminate the gaps in past research by obtaining an optimum methodology that will provide accurate and efficient outcomes. This research will generate a remotely applicable model that estimates the disease at an early stage.

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